

WHAT IS CLAIMED IS:

1. An organic light-emitting diode (OLED) device which produces substantially white light, comprising:
 - a) an anode;
 - b) a hole-transporting layer disposed over the anode;
 - c) a blue light-emitting layer having a host doped with a blue light-emitting compound disposed directly on the hole-transporting layer and the blue light-emitting layer being doped with an electron-transporting or a hole-transporting material or both selected to improve efficiency and operational stability;
 - d) an electron-transporting layer disposed over the blue light-emitting layer;
 - e) a cathode disposed over the electron-transporting layer; and
 - f) the hole-transporting layer or electron-transporting layer, or both the hole-transporting layer and electron-transporting layer, being selectively doped with a compound which emits light in the yellow region of the spectrum which corresponds to an entire layer or a partial portion of a layer in contact with the blue light-emitting layer.

2. The OLED device of claim 1 wherein hole-transporting or the electron-transporting blue stabilizing dopant material is selected to be in a range of from .5 to 10 percent by volume of the host material and when both are used, they are selected to be in a range of from 1 to 20 percent by volume of the host material.

3. The OLED device of claim 1 wherein the hole-transporting blue stabilizing dopants in the blue light-emitting layer are:
 - 1,1-Bis(4-di-*p*-tolylaminophenyl)cyclohexane
 - 1,1-Bis(4-di-*p*-tolylaminophenyl)-4-phenylcyclohexane
 - 4,4'-Bis(diphenylamino)quadriphenyl
 - Bis(4-dimethylamino-2-methylphenyl)-phenylmethane

N,N,N-Tri(*p*-tolyl)amine
 4-(di-*p*-tolylamino)-4'-[4(di-*p*-tolylamino)-styryl]stilbene
 N,N,N',N'-Tetra-*p*-tolyl-4-4'-diaminobiphenyl
 N,N,N',N'-Tetraphenyl-4,4'-diaminobiphenyl
 N,N,N',N'-tetra-1-naphthyl-4,4'-diaminobiphenyl
 N,N,N',N'-tetra-2-naphthyl-4,4'-diaminobiphenyl
 N-Phenylcarbazole
 4,4'-Bis[N-(1-naphthyl)-N-phenylamino]biphenyl (NPB)
 4,4'-Bis[N-(1-naphthyl)-N-(2-naphthyl)amino]biphenyl (TNB)
 4,4''-Bis[N-(1-naphthyl)-N-phenylamino]*p*-terphenyl
 4,4'-Bis[N-(2-naphthyl)-N-phenylamino]biphenyl
 4,4'-Bis[N-(3-acenaphthenyl)-N-phenylamino]biphenyl
 1,5-Bis[N-(1-naphthyl)-N-phenylamino]naphthalene
 4,4'-Bis[N-(9-anthryl)-N-phenylamino]biphenyl
 4,4''-Bis[N-(1-anthryl)-N-phenylamino]-*p*-terphenyl
 4,4'-Bis[N-(2-phenanthryl)-N-phenylamino]biphenyl
 4,4'-Bis[N-(8-fluoranthenyl)-N-phenylamino]biphenyl
 4,4'-Bis[N-(2-pyrenyl)-N-phenylamino]biphenyl
 4,4'-Bis[N-(2-naphthacenyl)-N-phenylamino]biphenyl
 4,4'-Bis[N-(2-perylenyl)-N-phenylamino]biphenyl
 4,4'-Bis[N-(1-coronenyl)-N-phenylamino]biphenyl
 2,6-Bis(di-*p*-tolylamino)naphthalene
 2,6-Bis[di-(1-naphthyl)amino]naphthalene
 2,6-Bis[N-(1-naphthyl)-N-(2-naphthyl)amino]naphthalene
 N,N,N',N'-Tetra(2-naphthyl)-4,4''-diamino-*p*-terphenyl
 4,4'-Bis{N-phenyl-N-[4-(1-naphthyl)-phenyl]amino}biphenyl
 4,4'-Bis[N-phenyl-N-(2-pyrenyl)amino]biphenyl
 2,6-Bis[N,N-di(2-naphthyl)amine]fluorene
 1,5-Bis[N-(1-naphthyl)-N-phenylamino]naphthalene
 4,4',4''-tris[(3-methylphenyl)phenylamino]triphenylamine (MTDATA)
 4,4'-Bis[N-(3-methylphenyl)-N-phenylamino]biphenyl (TPD).

4. The OLED device of claim 1 wherein the electron-transporting blue stabilizing dopants in the blue light-emitting layer are:

BAIq

Aluminum trisoxine [alias, tris(8-quinolinolato)aluminum(III)]

Magnesium bisoxine [alias, bis(8-quinolinolato)magnesium(II)]

Bis[benzo{f}-8-quinolinolato]zinc (II)

Bis(2-methyl-8-quinolinolato)aluminum(III)-μ-oxo-bis(2-methyl-8-quinolinolato) aluminum(III)

Indium trisoxine [alias, tris(8-quinolinolato)indium]

Aluminum tris(5-methyloxine) [alias, tris(5-methyl-8-quinolinolato)aluminum(III)]

Lithium oxine [alias, (8-quinolinolato)lithium(I)]

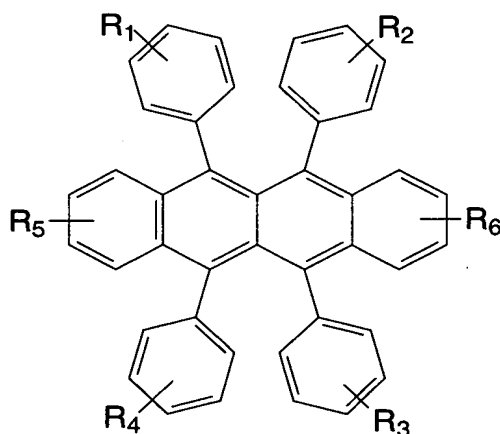
Gallium oxine [alias, tris(8-quinolinolato)gallium(III)]

Zirconium oxine [alias, tetra(8-quinolinolato)zirconium(IV)].

5. The OLED device of claim 1 wherein the hole-transporting blue stabilizing dopant material is NPB and the electron-transporting blue stabilizing material is Alq.

6. The OLED device of claim 1 wherein the hole-transporting blue stabilizing dopant material is NPB and the electron-transporting blue stabilizing dopant material is BAIq.

7. The OLED device of claim 1 wherein the yellow light-emitting compound is:



wherein R_1 , R_2 , R_3 , R_4 , R_5 , R_6 represent one or more substituents on each ring where each substituent is individually selected from the following groups:

Group 1: hydrogen, or alkyl of from 1 to 24 carbon atoms;

Group 2: aryl or substituted aryl of from 5 to 20 carbon atoms;

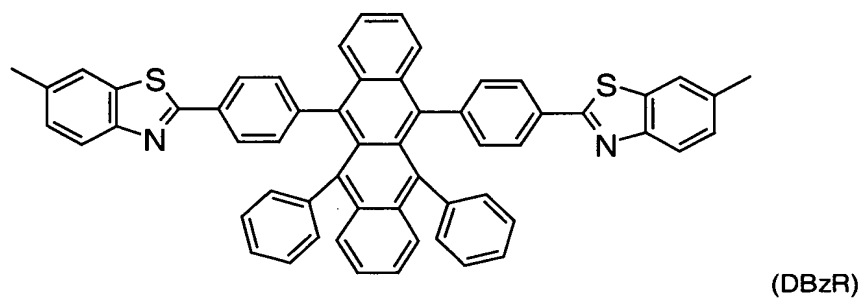
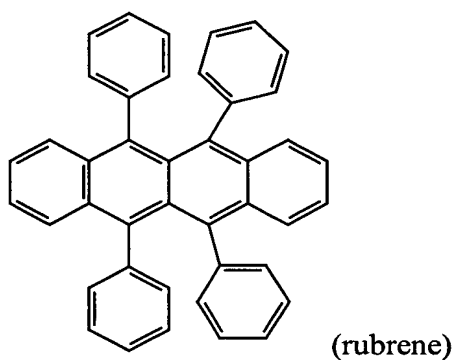
Group 3: carbon atoms from 4 to 24 necessary to complete a fused aromatic ring of phenyl, naphthyl, anthracenyl, phenanthryl, pyrenyl, or perylenyl;

Group 4: heteroaryl or substituted heteroaryl of from 5 to 24 carbon atoms such as thiazolyl, furyl, thienyl, pyridyl, quinolinyl or other heterocyclic systems, which may be bonded via a single bond, or may complete a fused heteroaromatic ring system;

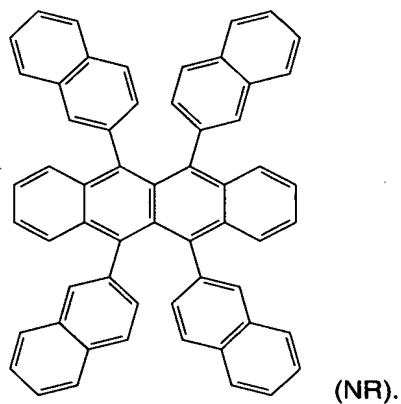
Group 5: alkoxyamino, alkylamino, or arylamino of from 1 to 24 carbon atoms; or

Group 6: fluorine, chlorine, bromine or cyano.

8. The OLED device of claim 6 wherein the yellow-emitting dopants includes 5,6,11,12-tetraphenylnaphthacene (rubrene); 6,11-diphenyl-5,12-bis(4-(6-methyl-benzothiazol-2-yl)phenyl)naphthacene (DBzR) or 5,6,11,12-tetra(2-naphthyl)naphthacene (NR), the formulas of which are shown below:



or

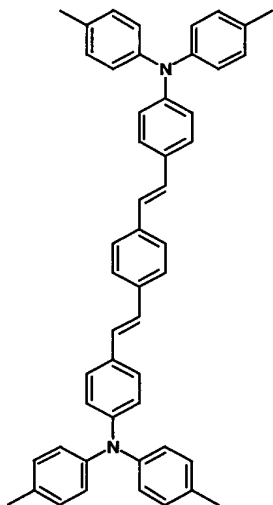


9. The OLED device of claim 7 wherein the concentration of yellow-emitting dopants 5,6,11,12-tetraphenylnaphthacene (rubrene); 6,11-diphenyl-5,12-bis(4-(6-methyl-benzothiazol-2-yl)phenyl)naphthacene (DBzR) or 5,6,11,12-tetra(2-naphthyl)naphthacene (NR) is in a range of greater than 0 and less than 30% percent by volume of the host material.

10. The OLED device of claim 7 wherein the concentration of yellow-emitting dopants 5,6,11,12-tetraphenylnaphthacene (rubrene); 6,11-

diphenyl-5,12-bis(4-(6-methyl-benzothiazol-2-yl)phenyl)naphthacene (DBzR) or 5,6,11,12-tetra(2-naphthyl)naphthacene (NR) is preferably in a range of greater than 0 and less than 15 % percent by volume of the host material.

11. The OLED device of claim 1 wherein the blue dopant includes distyrylamine derivatives as shown by the formula

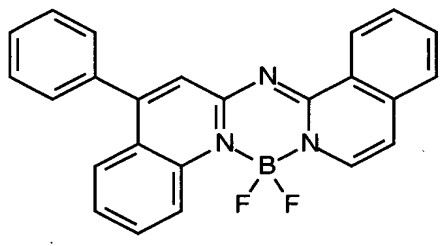


12. The OLED device of claim 1 wherein the blue emitting dopant further includes perylene and its derivatives.

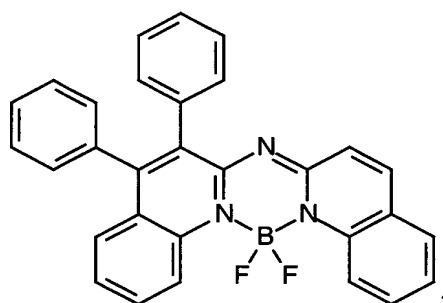
13. The OLED device of claim 12 wherein the perylene derivative is 2,5,8,11-tetra-tert-butyl perylene (TBP).

14. The OLED device of claim 1 wherein the blue dopant is represented by the following formulas:

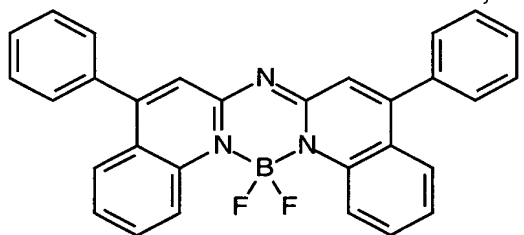
B-2



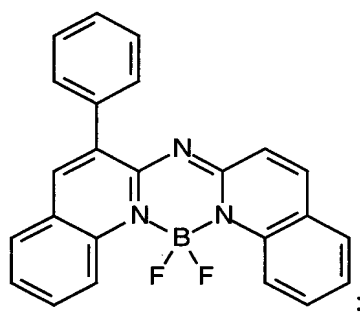
B-3



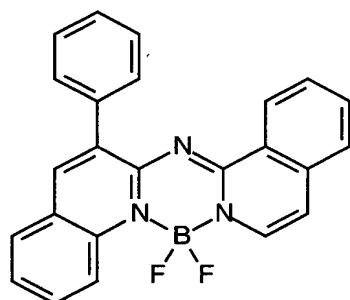
B-4



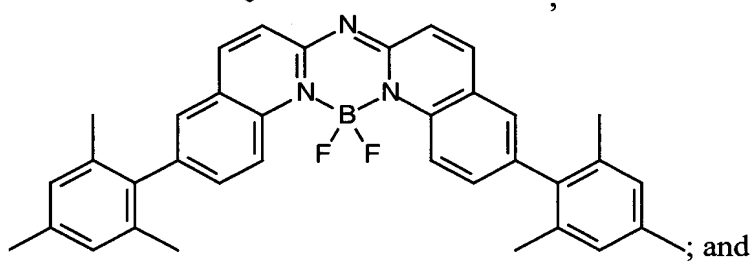
B-5



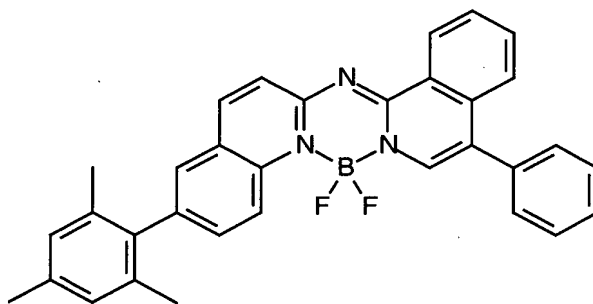
B-6



B-7



B-8



15. The OLED device of claim 1 wherein the concentration of blue emitting dopants, is in the range of greater than 0 and less than 10% percent by volume of the host material.

16. The OLED device of claim 1 wherein thickness of the hole-transporting layer is between 5 nm-300 nm.

17. The OLED device of claim 1 wherein the hole-transporting layer includes two or more sublayers, the sublayer closest to the blue light-emitting layer being doped with yellow-emitting dopants.

18. The OLED device of claim 17 wherein the dopant in the hole transport material is 5,6,11,12-tetraphenyl-naphthacene (rubrene); 6,11-diphenyl-5,12-bis(4-(6-methyl-benzothiazol-2-yl)phenyl)naphthacene (DBzR); or 5,6,11,12-tetra(2-naphthyl)naphthacene (NR), and the thickness of the layer containing yellow dopant is in a range between 1 nm-300 nm.

19. The OLED device of claim 1 wherein thickness of the blue light-emitting layer is in a range between 5 nm-100 nm.

20. The OLED device of claim 1 wherein a hole-injecting layer is provided between the anode and the hole-transporting layer.

21. The OLED device of claim 20 wherein the hole-injecting layer comprises CFx, CuPC, or m-MTDATA.

22. The OLED device of claim 20 wherein the thickness of hole injecting layer is 0.1 nm-100 nm.

23. The OLED device of claim 1 wherein thickness of the electron-transporting layer is in a range between 5 nm-150 nm.

24. The OLED device of claim 1 wherein the cathode is selected from the group consisting of LiF/Al, Mg:Ag alloy, Al-Li alloy, and Mg-Al alloy.

25. The OLED device of claim 1 wherein the cathode is transparent.

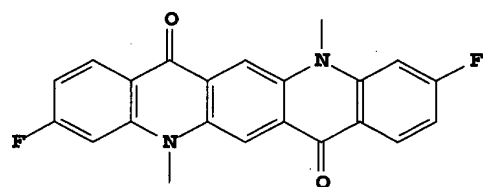
26. The OLED device of claim 1 wherein the electron-transporting layer is transparent.

27. The organic light-emitting diode (OLED) device of claim 1 wherein the electron-transporting layer is doped with a green light-emitting dopant or a combination of green and yellow light-emitting dopants.

28. The OLED device of claim 27 wherein of the green dopant in the electron-transporting layer includes a coumarin compound.

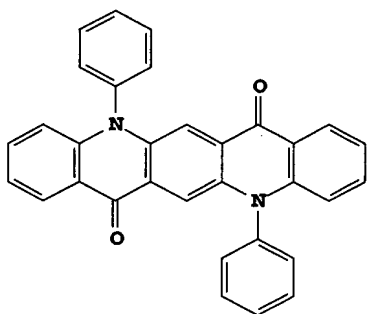
29. The OLED device of claim 28 wherein the coumarin compound includes C545T or C545TB.

30. The OLED device of claim 27 wherein the green light-emitting dopant has the formula:



G-1

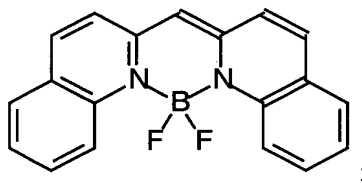
or



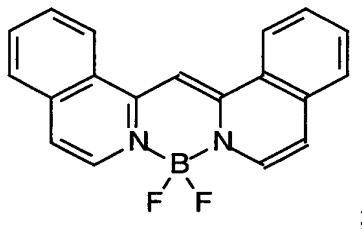
G-2

and compounds suitably represented by formulas:

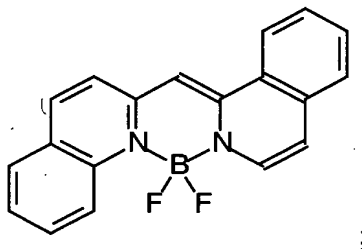
G-3



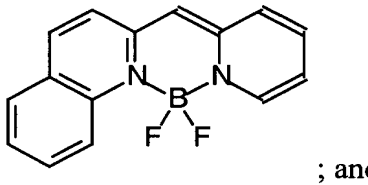
G-4



G-5



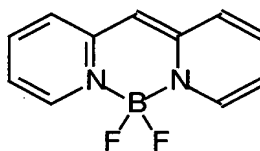
G-6



; and

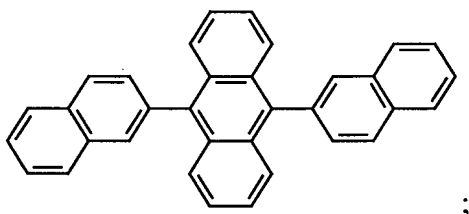
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G-7

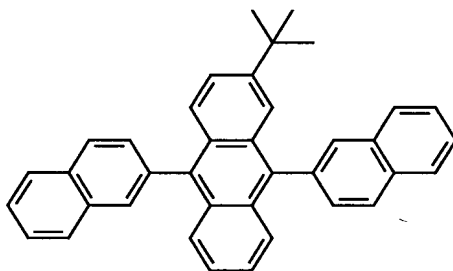


31. The OLED device of claim 27 wherein green dopant concentration is between 0.1-5% percent by volume of the host material.
32. The OLED device of claim 1 further including buffer layer disposed on the cathode layer.
33. The OLED device of claim 32 wherein thickness of the buffer layer is in a range between 1 nm-1000 nm.
34. The OLED device of claim 1 further including a color filter array disposed on the substrate or over the cathode.
35. The OLED device of claim 27 further including a color filter array disposed on the buffer layer.
36. The OLED device of claim 1 further including thin film transistors (TFTs) on the substrate to address the individual pixels.
37. The OLED device of claim 1 wherein the hole-transporting layer includes an aromatic tertiary amine.
38. The OLED device of claim 1 wherein the electron-transporting layer includes copper phthalocyanine compound.
39. The OLED device of claim 1 wherein the blue light-emitting layer includes host material selected from the group consisting of:

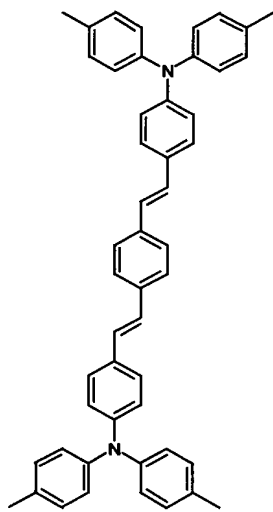
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or



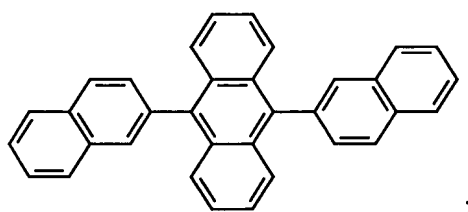
; and a blue light-emitting dopant includes



or derivatives thereof.

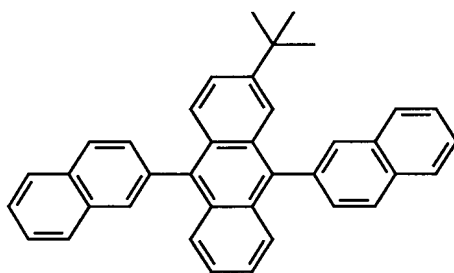
40. The OLED device of claim 1 wherein the blue light-emitting layer includes host material selected from the group consisting of:

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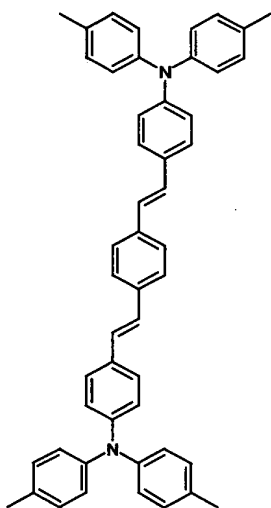
;

or



;

a blue light-emitting dopant includes



or derivatives thereof.